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Research article

Landscape dimension in the built environment: The spatial operative of an integrated micro agriculture unit

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ABSTRACT

The rapid urbanization creates an increased demand for food supply and security in urban system. The imminent risks stemmed from climate change appeal for a greater effort in an overhaul of the customary practices in the planning and management of the urban systems. Urban centers should accommodate the growing need for green infrastructure and edible landscape; options such as farming alternative has gained interest as a possible solution to the urban-scape and the food production stability for the urban inhabitants. This article presents the systemic approach to building integrated agriculture unit prototype's design thinking and proposed a prototype model allowing the locality and place to be incorporated into the design framework. The research concludes that: (1) in line with human-nature connection and raising its priority level within both design research and design practice should consider the environmental, social, economic and spatial criteria for the design thinking exploration; (2) the design results in a flexible system model of the micro building integrated agriculture unit, allowing the units to fit either indoor or outdoor, as a probable solution suited for the locality and the increasing demand for edible greens; (3) indoor units need further study in integration with the indoor climate control and automation as well as added indoor air purification and sensor functions. (4) Prototype units should be capable of providing locally available edible production and social well-being for the urban system.

1. Introduction

The vast majorities of humans enjoyed an agrarian lifestyle prior to and right after the industrial revolution (see Table 1). The urbanization afterward accelerates to an inevitable urban growth and sprawl accompanied by the disappearance of urban-fringe farmland. This condition propelled the imbalance in the supply and demand for food production in urban areas. The explosion of demographic growth encroached the urban food safety and production capacity further in developing countries. This caused a grave impact on low-income families in need of wholesome, affordable produce and better living quality. The UN called to challenge the artificial urban-rural dichotomy and work to mainstream a territorial approach to development (UN, 2017). To grapple with the rapid explosion of the global urbanization, the target is set per given city-specific goal to ensure cities to be inclusive, safe, resilient and sustainable (UN, 2017). By 2030, urban centers should implement through the thorough integration of urban green in enhancing the health and well-being of the urban residents.

The term 'urban' needs to be understood in its broadest sense: encompassing metropolitan areas, intermediary cities, peri-urban regions, and the rural surroundings with which they are inter-dependent (Tau, 2017). We witnessed how agriculture's role as the primary use of land resources weakened its influence in urban areas. Cities consumed a staggering amount of the agricultural land (Anonymous, 2015a) for infrastructure, housing and industries use. The extension of the urban perimeter evidently cuts further into available productive ground and encroaches upon important ecosystems (Obaid, 2007). A gap is observed in the stipulation of adequate urban green features. Issues on health intensified the observed human-nature connection and raised its priority level within design research and practice. A comprehensive rethinking of architecture urbanism to develop sustainable and ecological urban spaces should be re-thought out.

The phenomenon of growing urban edible green has had a lengthy history in human civilization. Well-functioning urban food systems constitute a core component of enabling citizen well-being (White and Hamm, 2014). Edible greens promote numerous social and environmental benefits, like food security, waste management, increased health and nutrition to the provision of thriving public space (Rees, 1996;

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Table 1
Edible landscape/agriculture typology.

Typology	Functional Consideration& Method	Intervention Effect
Vertical Edible Greening	Greening hard, urban surfaces either in soil or substitute medium. Edible greens planted in pockets or containers.	Increased building insulation, cooling, and soundproofing
Hydroponics	Growing of plants without the use of soil with nutrient-rich water solutions.	
Greenhouses	Added structure to existing site or building for the singular function of planting with internal micro-climates control.	integrates greenhouse structures or creates dedicated buildings
Roof gardens	Movable or temporary addition to rooftops. Can be part of green roof.	reduce building energy cost through insulation and the cleaning of storm water
Public Edible urban greenery	Part of the functional and aesthetic landscape of the city, providing edges and greening in urban public spaces.	Part of an urban forest scheme.
Private urban /community Garden	Gardened by individual or a group of people. The community garden usually is a collective empowerment initiative	Integrated in a network of sharing and learning together.
Interior edible greening	As an independent added element in the interior of building	Grow edibles in cycle; automated control thru IoT

Burke, 2010; Smit and Nasr, 1992; UNDP, 1996; Girardet, 2005; Lawson, 2005; Mougeot, 2006; Hou et al., 2009). Though the development of the urban landscape infrastructures could allow for the facilitation of functional, social and ecological interactions (Nijhuis and Jauslin, 2015), urban planners and landscape designers, however, are often ill-equipped to integrate the green landscape and food-systems thinking into future for cities (Lovell, 2010). The urban-scape densification challenged policymakers to incorporate adaptive accommodation of green features and edible landscape as they have become a scarce commodity ever more important but only afforded by the city's well-to-do.

The aesthetic function of urban agriculture as an issue has received little attention in previous research (White and Hamm, 2014). The necessity and manifestation, however, is evident in many urban planning models that offer an alternative land use for integrating multiple functions in densely populated areas (Lovell, 2010). Climate change brought forth a more significant challenge to humans and the environment; the design thinking swiftly calls for social responsibility and ability to cope or adapt to the drastic changes ahead. The purpose of this study is to stipulate the edible landscape as an available tool in satisfying greening urban-scape and food production. This issue should be included during the design thinking process for architecture and urban planning; the consideration includes all aspects of the neighborhood context incorporated into the architecture design elements such a vertical green walls and interior interactive green features. The edible landscapes should adopt both to physical human use and human sensibilities, whether because of its environment or people specific lifestyles.

In this study, we used systemic design thinking to discuss the spatial, environmental, social, economic dimensions of urban edible green. The initial focus was placed on the urban farming literature in the last decade to gather its potential benefits and ecological challenges. Case studies, as well as design criteria consideration, are reviewed. The material and methods section analized the precedents and considered the spatial design criteria. The contemplation is narrowed into the architectural component through the use of horizontal and/or vertical elements in buildings to allow the implementation of edible greens, mainly applicable to living walls or interior micro-units. In the result section of this paper, we discussed the implementation process of the design attributes, followed by a case study prototype and consideration for micro building integrated units. In the discussion, we dissected the effect of such consideration followed by the conclusion of this research.

2. Material and methods

The primary goal of this section was to ascertain the value of edible agriculture in the urban system. We determined the consideration and criteria relevant to designing integrated edible green and design prototype. Another objective was to understand the wide range progress and practices. We attempted incorporating the diverse approaches as part of the changing times, user needs, and locality differences. This is expressed in the spatial location within the urban context and social form. The design contemplation from the landscape dimension considered the systemic design thinking; refinement of the typology and scale of the said integrated prototype, followed by determining the attributes of the design. The outline of this section is as follow (1) review on integrated edible green and urban landscape; (2) systemic design thinking and (3) prototype design attributes.

2.1. Integrated edible green and urban landscape

The primary purpose of the edible landscape is to re-integrate food production back into the city's life. This can lead to a reconnection of people with their food system and urban green and promotion of a more active lifestyle. Urban agriculture as research and dissemination began in the late 1970s (Bohn and Viljoen, 2011). The UN Development Program (UNDP), International Network of Resource Centers on Urban Agriculture and Food Security, and other public institutions analyzed the functions of urban agriculture through case studies since the 1990s. The specific concept such as the Continuous Productive Urban Landscape and agriculture urbanism (Vilijoen et al., 2005; de la Salle and Holland, 2010) was considered. Decidedly, the edible landscape could equally have contributed toward food security as a contributing part of the social equilibrium and stability (Çelik, 2017). The diverse definition of urban agriculture has been proposed stressing on the relationships between agriculture and the city both in terms of resources and outputs (Lourenço-Lindell, 1996; Moustier and Mbaye, 1999; Moustier and Fall 2004) “Urban agriculture” or “edible landscape” are defined as the growing of plants and the raising of animals for food and other uses within and around cities and towns (Van Veenhuizen, 2006).

Urban farming represents a type of urban agriculture that has a primary emphasis on income-generating agricultural activity. It differs from other types of urban agriculture such as home gardens and community grounds. The particular distinction lays in that food is produced for commercial distribution rather than for consumption. The dible landscape thus can also be regarded as a part of the greening strategy, using spatial dimension to green. Edible plants and other landscape plants can foster a multi-functional place (Bhatt et al., 2009: Barthel and Isendahl, 2013). The use of vertical greening is the result of the integration of vegetation and building. This improves the ecological and environmental efficiency with beneficial influence not only on social and aesthetical value but also on well-being in and around the buildings (Rakhshandehroo et al., 2016). However, questions about whether and how to develop research and development activity for this agriculture or urban greening method as it remains largely untested (de Bon et al., 2010).

Edible landscaping is oftentimes called food-sapping and is a progressive food systems approach that encourages all people in their homes, communal spaces and workplaces to promote local food (Thompson and Sokolowski, 2016). Historic arguments made prior to

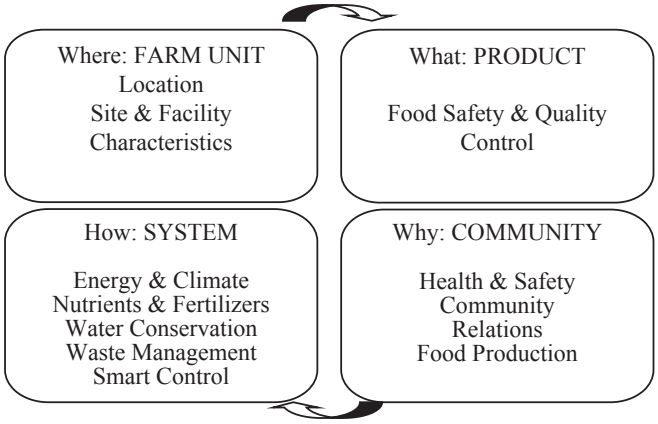

Fig. 1. The urban agricultural cycle.
Source: Columbia University, 2016 and adapted for this study

the petrochemical era yield evidence for the advantages of locating fruit and vegetable production adjacent to urban areas. The writing of Johann von Thünen, first published in 1826 promoted the notion that agricultural produce land should be allocated near the urban core. The study conducted by Columbia University (2016) calls for 7 key attributes for assessing the sustainability of urban agriculture and identified 9 key sustainability principles (Columbia, 2016). The nine core principles are: (1) health and safety/operating conditions; (2) food safety and quality assurance; (3) pest management and pesticide use; (4) nutrient management and fertilizers; (5) water conservation and management; (6) community relations; (7) waste management; (8) energy and climate; (9) site and facility characteristic. (See Fig. 1 below). The interrelation is further divided into 4 categories of farm, product, system, and community. In thinking of Building Integrated Agriculture in mixed-used building or ”zero-acreage farming”, includes farming that does not utilize farmland or open spaces (Columbia, 2016); the consideration cycle is shown below (Fig. 1).

The United Nations' Food and Agriculture Organization (FAO) warned that, in the future, the 12 mega-cities of 10 million-plus population will experience increasing difficulty in feeding themselves (Viljoen et al., 2005). The edible landscape then could play a pivotal role in re-inviting food production back into the city's life. This enables the reconnection of people with their food system to promote a healthier lifestyle. One example is the Pasona's “Urban Farm”. It officially opened in early 2010 in partnership with Kono Designs based in NYC, as an offshoot of their “O2” underground space that showcased innovative city farming. Plants are grown in either soil-based or hydroponic based method. The strategy to fit into the home environment and to be individualized in a domestic setting, as the micro-farm unit could be small and self-contained as an independent system. Allen's studies from the 1990s refer to the patchy nature of cities, prompted the idea that agriculture could fit into the contemporary urban fabric (Viljoen et al., 2009). Contextual place's specific information can be incorporated to tailor local adaptations thru time; this progressively contributes to the change of time and improvements, completing the adaptive process of greening the urban-scape. Edible landscaping, which integrates food-producing plants into ornamental plantings and conventional designs, is also put forward as a productive landscaping alternative (Kourik, 2005). Many studies have shown associations with the edible landscape activities, the health (physical and psychological), social, economic, and ecological benefits. Edible landscaping provides a means of preserving and enhancing the existing functions of urban green areas while generating a production yield and creative work.

The comparative similarities and differences on vertical farms, urban and non-urban application, scale differential through the design debate focused on edible green infrastructure. The expression in architecture is exemplified by the notion of infrastructural urbanism (Allen, 1996). As urbanization accelerated the loss of agricultural land (Çelik, 2017), the sprawling effect has engulfed the surrounding agricultural lands and small villages (Thuo, 2010). The result lays in significant changes in agricultural land and its land use, directly affecting the landscape, resulting in a mix of urban and agricultural land uses (Malaque and Yokohori, 2007). The decrease of the arable land area is a direct consequential result for urbanized amenities characterized by zoning policy for industrial, infrastructural, brownfield zones and abandoned lots. The synergy and efficient use of agriculture and building, wastewater and waste heat is evident. Aside from the reduction of land sued by traditional agriculture, edible greens allow for a restoration of the local ecological condition. The spatial and functional variations corresponding to temporal characteristics of the place or to patterns of a habitual note and human interaction are clear. The green agenda defines the landscape dimension within the urban-scape while the brown agenda assumes the human interaction within. The intervention within the green infrastructure of the urban system calls for the optimization of land use, engineering of waste systems, the minimizing of energy consumption and transport, the reduction in use of materials and the creation of an efficient built environment (UN, 2010), while maintaining the flexibility between the green and brown agenda system. The use of obsolete infrastructure is New York's High Line; it is built on the remains of an abandoned elevated train line spur. Initially designed to cut through blocks and not follow the street, allowing freight to be easily delivered to factories and other businesses, the new design fulfills the need for the green agenda along the brown agenda.

2.2. Systemic design thinking

The systems thinking is applied to the issues of edible landscape within the built environments. The practice derives from systems theory, which calls for a trans-disciplinary investigation of the abstract organization of phenomena; this must be independent of their substance, class, or spatial organization. The thinking reveals principles common to all complex phenomena and provides a foundation for models for depiction and management. It is not a particular theory or approach, but rather a conglomerate of theories and approaches. Systems thinking evolved as an alternative to the dominant “mechanistic” view of the world. The material universe is seen as a machine and holds that all aspects of complex structures can be understood by reducing them to their smallest parts (Capra & Luisi, 2014). Systemic design derives from user-oriented and service design practices, integrating human-centered design. Core ideas in the design consideration include connectivity multi-functionality and ‘‘green” edible landscapes as part of the residential landscape, community garden, urban green areas. The thinking could be categorized a follow:

The development of system thinking has undergone refinement to include descriptive orientation/or explanation, prediction oriented/or control, and intervention/change. Considerably, the development should include learning oriented and social change oriented thinking (Jackson, 2010). When exploring the essential conditions for the current form of the edible landscape in cities thru systemic thinking, the relationship to the environment is examined. The prevailing thinking should be revolted and reconsider criteria on the sensibilities and practices necessary to enhance our linkage and practices. This should include the retrofitting with existing urban-scape condition as well as plan for the cities of the future (Mostafavi and Doherty, 2010). The building-block approach should fit many interior conditions to offer for year-round production with low water consumption and pesticide-free growth cycle. Having green-scape nearby can increase improvement in health (Groenewegen et al., 2006). In terms of the scale of edible landscape, having determined the typology strategy can be subdivided as follows (see Table 2):

The criteria consideration process should define the role played by the design prototype within the urban context. Whether it is part of the urban landscape with agricultural output and how it plays with the

Table 2
Scale of urban agriculture.

Scale	Example of Scale	Place Acceptance
Micro	Interior units Green roofs, walls, courtyard Back yard Street green strip	The interior units are being sold on market in the past two to three years; green roofs, walls have been widely applied in buildings sine 1990s
Meso	Community garden Individual collective gardens Urban parks and green	The possibility of integration with outdoor open green system.
Macro	Commercial scale farms, orchard, grazing Nurseries Greenhouses	As a production system, especially in highly developed cities or urban areas in extreme environment

building fabric. The following topic to be considered comprises the scale and acceptability of which is the place it is to be located. The decision to place the unit in the exterior or interior of the building is critical during the design development process. It is advised to define the design function in the Brainstorming stage during the systemic design consideration.

The consideration of the social–ecological paradigm of the design process should focus on the possible contribution and spatial reference issue as part of the transactional transfer based on the ongoing exchanges among people and environments that occur across varying times and scales (Stokols et al., 2013). By incorporating the temporal and spatial attributes, the defined parameter for the spatial scale within the system is critical in allotting the attributes, developing the approach a place-based method (Ling and Chiang, 2017). The design criteria assume a stable functional system, whether it is the soil, water or nutrient supply, as the technical supply component is excluded from the spatial design consideration. The key is to target the key components. Therefore, attention is paid to the relationships among the four attributes of environmental, spatial, economic and social relevance. Prior to the design development, the environmental, spatial and social dimension are considered, with the final intention of finalizing the strategy for the design (Fig. 2):

The feature issues of form, scale, spatial attribute, and activity are included to propose the design thinking for edible greening fitted to the need. Finally, the design criteria must consider the aesthetic analogy with nature; nature includes living organisms and non-living components of an ecosystem, inclusive within the habitat. When approaching architecture in the biophilic perspective; we devised three features to be discussed: 1) that of nature of the space, 2) natural analogues and 3) nature in the space (table below) (see Table 3).

Nature of the Space addresses the observable spatial configurations. Nature in the Space addresses the direct, physical and ephemeral presence of nature in a space or place. Natural Analogues addresses organic, non-living and indirect evocations of nature like objects, materials, colors, shapes, sequences, and patterns found in nature; they are manifested as artwork, ornamentation, furniture, décor, and textiles in the built environment. The example of the 'Nature Analogues' includes such design measure as Singapore's 'Skyrise Greenery' program, which is an example of using building components for greening purposes; other examples are living wall and interior micro edible farm. A cross of 'Nature Analogues' and 'Nature in Place' is in Bohn and Viljoen's proposal in a design method called Continuous Productive Urban Landscape (Viljoen, et al., 2006; Viljoen and Bohn, 2014). The design advocated the articulated inter-linkage of productive landscapes into the urban system as an essential element of sustainable urban infrastructure. The green corridors as a continuous network of productive open space can include footpaths and cycleways. This is an example of 'Nature of the Space', where vacant lots or infrastructure is taken over for greening purposes.

The systemic and adaptive thinking for the ethics-aesthetic principle required a far greater design input for alternatives: caring for the creative ways to examine the need and functions for the city ecologically. Design criteria should consider spatial features and activities for an inclusive design philosophy of urban agriculture; this include outdoor spaces for people (leisure and commercial), natural habitats, ecological corridors and circulation routes for non-vehicular traffic as part of the program criteria.

2.3. Prototype design attributes

Though the tools to evaluate the quality of urban green spaces are still being developed (Haller et al., 2013), the design requirement in developing an urban edible agriculture unit presents several logistic and technological challenges such as zoning, maintenance, farm management and the actual prototype design. Overall, there is a need for a systemic thinking in the design integration within the urban confine. The target is to reduce the environmental impact of architecture and ecological footprint research (Wackernagel and Rees, 1996). The design prototype needs to refine and accentuate the realized form and function in four dimensions: 1) the environmental issue that should consider the

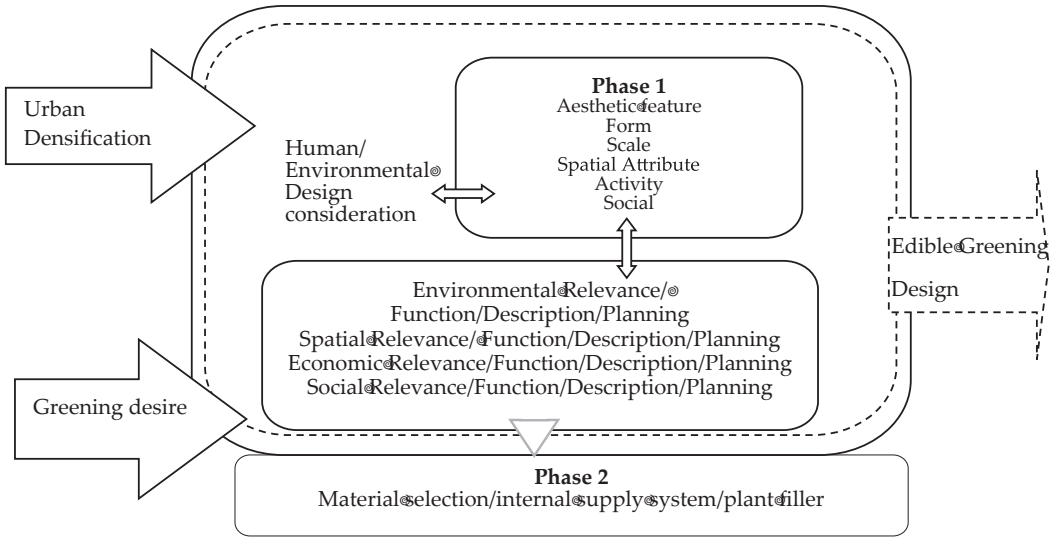

Fig. 2. Edible Green Design criteria process.

Table 3
Design features in edible greening design.

Aesthetic Feature	Form	Scale	Spatial Attribute	Activity
Nature of the Space.	Open space adjacent to building	Medium to large	Visual impact high thru streetscape, alleyways and vacant lots	Urban farming and gardening; foster community outdoor activities.
Natural Analogues	As part of building vertical plane with biomorphic forms and patters and connection with nature	Medium to large; often need to consider the structural feature, waterproofing and function	Highly impacted visual feature that enhance the appearance and neighborhood character	
	As part of building horizontal plane	Medium to large; as roof garden the structural loading and waterproofing need to be considered	Garden or backyard edible contribute to the greening feature	
Nature in the Space	Building Interior element	Small to Medium	As an element in the interior spatial framework such as interior wall	
	small, Micro-restorative Visual and Non-Visual Connections with Nature	Small	Mobile in character as an object within the space	

biodiversity, wasteland incentive, energy conservation and microclimate control; 2) the spatial issue that considers the place identity, horizontal, vertical and visual enhancement; 3) Economic issue that considers the revitalization and production value and lastly 4) social issue that considers the community, human, cultural and education In incorporating the integrated agriculture unit thinking for the challenging urban environment, and the Columbia (2016) research consideration, the attributes needed to consider during the design phase are as follow (see Table 4):

For the consideration of the design, the integrated agriculture unit within the urban area should combine the notion of 'space' as the bridging criterion. The design spans across urban edible green system planning and urban planning. These categories immediately carry the necessary form scale, attribute feature, and activities that could happen with edible green. Incorporation of urban agriculture into the urban environment will enormously improve the sustainability of cities. Jointed advantages do add to the multiple services cities can provide (Rosa et al., 2014). The typology, scale, and the four necessary attribute issues are incorporated; the strategy for considering the landscape dimension of the integrated agriculture prototype must be befitting to the place and community. The process for the design consideration assumes the scale for the edible green prior to the actual assessment. Upon deciding the required design features, the attributes relevance should be integrated. Further, the exploration process, the materials, internal technical supply system and construction method ought to be considered.

3. Result

3.1. Discovery and interpretation on going micro

We have undertaken the typology exploration and the study approach consolidated on a system unit design thinking that allows flexibility in the application of the integrated agriculture unit; the design is to be placed either independently on the exterior or as part of the interior spatial feature. The basic size of the standard unit should allow future additive elements to expand and consolidate the system in a holistic manner. The standard unit is defined as a micro-unit; it is a flexible system that could be placed in unused city space or interior space for the agricultural purpose. The prime aim is to produce crops or to green the surrounding. The micro-unit should accommodate the planting choice; the design should be diverse, dependent on the local place and needs, frequently composed of vegetables and herbs and not commodity crops.

The design development began on defining the micro-unit as the most approachable and implementable scale-wise and applicable to a range of the site. Spatially, it can be used by each household in contribution to the edible landscape and part of the urban food production network. Ultimately, it may contribute to a broad range of activities and the diversity of the urban landscape. The interpretation intended is to allow the dual unit to form the holistic volume spatially for the microfarming unit. They behave as the foundation and logical skeleton, upon which the subsequent growth can be supported. Recognizing the typical patterns early on will speed up the language's development, and guide it in the proper direction. (Salingaros, 2014). Having set the pattern, the critical issues in consideration are: (1) aesthetic; (2) form; (3) scale; (4) the spatial attribute and (5) activities that can enhance in the environ both in research and practice; the aesthetic conception is derived from the discovery of pineapple geometry that can be subdivided into the more minor component (see Table 5).

Given the criteria selection, further detail should be placed on the functional aspect of the design in the second phase. However, the technical function would need to be further explored and will not be included in the spatial design operative process.

Table 4
Design attributes consideration for edible landscape.

Issues	Function	Description and Justification	Supportive Planning Strategies
Environment Relevance (Where)	**Biodiversity**	Agricultural systems support a wide range of species, including some native plants, as crops or associated plants.	Convert some open space areas of low diversity (*i.e.*, turf) to community gardens and farms.
	Waste land incentive	Urban infill land or abandoned land could be used for urban farming	Greening of open space or abandoned lot for garden and farm
	Energy Conservation	Producing food locally reduces the embodied energy resulting from inputs, transport, and packaging.	Develop transportation systems and networks to efficiently get food to consumers. Using drip system can induce water saving
	Waste Management	Organic waste products can be composted and used as a fertility resource for growing food and other products.	Identify systems to collect, divert, and transport organic wastes away from landfills to urban agriculture.
	Microclimate Control Urban heat island	Urban agriculture can positively alter microclimate through humidity control, wind protection, and shade.	Allow edible plantings in built areas to combat the heat island effect and other unfavorable climatic conditions.
Spatial Relevance (How)	**Place Identity**	The contextual enhancement of the local place thru the greening of the environment.	Gather the local criteria in sustaining the place identity making thru design provision.
	Horizontal Urban Greening	Community and backyard gardens contribute to the greening of urban areas, improving aesthetics and well-being.	Support efforts to convert vacant and derelict lands into productive green spaces for use by residents.
	Vertical Urban Greening	Building wall-interior or exterior could be used as the medium for vertical greening	Vertical greening method, either direct or indirect structural support
	Visual enhancement	Vertical green can enhance the visual experience of the environ	Using strategic 3D design for the enhancement of the local context
	Multi-functionality	Integration of multi-function in the design. The impact of material selection and ecological effect should be analyzed	Consider value added program or activities. Locally based material and its re-usability is prioritized.
Economic Relevance (What)	**Economic Revitalization**	Urban agriculture ventures offer new jobs for neighborhood residents and vitality from improved economics of the community.	Create networks to connect laborers, farmers, and markets to help retain and grow new ventures.
	Production/farm to table program	Urban agriculture produces fruits, vegetables, mushrooms, herbs, medicinal plants, meats, milk, cheese, eggs, and other products.	Provide suitable, accessible, and safe land with good solar access and an irrigation source. Reduction in greenhouse gas emissions from localized consumption
Social Relevance (Why)	**Community Socialization**	Community members often find gardening and farming to be a social activity through sharing food, knowledge, and labor.	Along with community garden spaces, integrate other activities and features to encourage socializing.
	Human Health/food safety	In addition to the known benefits of access to green space, urban agriculture offers healthy food and encourages physical activity.	Explore opportunities to develop community programming around gardening/farming as a healthy lifestyle.
	Cultural Heritage	Urban agriculture can provide access to rare ethnic foods that are typically not available in existing markets.	Integrate community garden spaces in areas known to have high immigrant populations, and link with culture.
	Education/Art contribution	Children and adults learn about foods, nutrition, cooking, environment, economics, and cultures through urban agriculture.	Offer gardening and urban agriculture activities within existing programs, particularly during summer.

3.2. Micro unit spatial operative design dimension

Developing an interdisciplinary strategy at the onset of the design process is imperative for the result that best answer the design. The unit configuration should accommodate the functionality criteria and the crop diversification as well. Based on the scale and typology decision, the attributes assessment evaluates the importance of the criteria considered. The whereabouts, what, how and why for the initiation of the design are taken into account. The prototype criteria, in this case, are to stay at the micro level; this means that the prototype can be designed for interior or exterior purpose. This study explored the dimensional flexibility in the systemic thinking; the decision is to stay within the modular thinking of a microunit. The allowance is given for the unit to be multiplied in scale. The prototype design called for the micro-farming units that can be accessed in the home or stack up vertically; produce could be shared or donated to local food banks (Balmer et al., 2005). The rise in food and health literacy is also noted with access to urban agriculture (SPUR, 2012), raising nutrition awareness and increased healthy consumption and eating habits. In places where fresh produce access presents a challenge, such as ship vessels or extreme climate zones, micro-units become a necessity. Prototype's functions in the environmental, spatial, economic and social dimensions could result in the positive contribution toward the urban landscape greening strategy. The employment of the “space” as the bridging parameter in the arrangement of the prototype allows for diversified application and design solution. The flexibility of the modular design provides multiple solutions to the urban core.

Our prototype design assessment encompassed the attributes assessment as follows (see Table 6):

3.3. Micro unit prototype exploration

The study explored the criteria and considerations and the spatial proposal system is as followed in Figs. 3–6. Based on concept derivation to prototype system, we proposed a design that begins with a modular thinking derived from nature.

Table 5
Edible micro unit design prototype criteria review.

Prototype Criteria	Aesthetic Feature	Form	Scale	Spatial Attribute	Activity
Micro Prototype Proposal	Allow for expanded role aesthetically	Flexible unit that can be added to larger unit	Smallest unit can be place in interior but able to fit the exterior to medium size	As an interior piece in the smallest unit. Can become a sculptural unit outdoor.	Allow as a decorative element in the interior and play piece incorporated in outdoor environment

Table 6
Prototype design assessment result.

	Function	Description and Justification	Supportive Planning Strategies
Environment Relevance	Biodiversity Micro Climate Control	Allow a variety of crops depending on the size of the unit. Add on to the greening and landscape value	open space design if it is placed on the exterior
Spatial Relevance	Place Identity Multi-functionality	The unit begins to contribute to the local place identity	Could be independent and assisting in the place identity of the given locality
Economic Relevance	Production and farm to table program	As an exterior unit it can provide a variety of produce as it can expand vertically, adding a production value to the users.	By giving the economic relevance to otherwise vacant lot or rooftop is a positive contribution in the locality
Social Relevance	Community Socialization Education/Art Contribution	A supporting role to accommodate community interaction and activities Learning by doing and serves as a learning stage for urban farming	Allow for multiple activities that could foster the socialization among members of the community. Should allocate space for observation and for planting as well as other learning activities

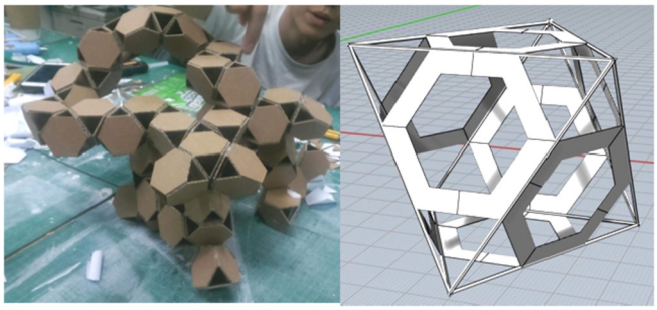

Fig. 3. Form Concept stage derivations.
Source: AJL Design Studio team (AJL, 2016)

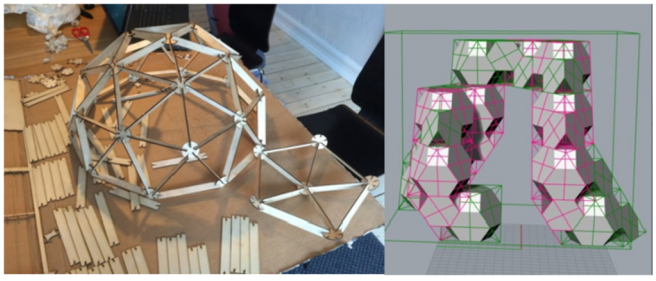

Fig. 4. Scale and System formation derivation.
Source: AJL Design Studio team (AJL, 2016)

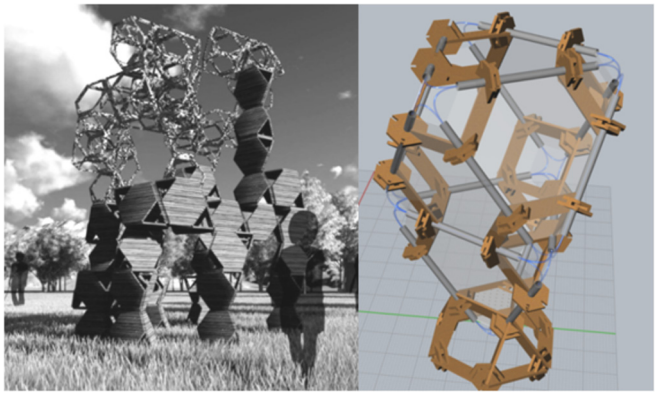

Fig. 5. Spatial Design Exploration derivations.
Source: AJL Design Studio team (AJL, 2016)

The concept called for the reuse of abandoned lots for the productive mixture, using agriculture as a medium for aesthetic and visual means. This is the perfect mix of green and brown agenda. In term of scale, a conceptual inception is a prototype unit that can be added on as per the site and function criteria. The minimum size is 60*60*60 cm with a smaller attached unit of 30*30*30 cm. Both units work together

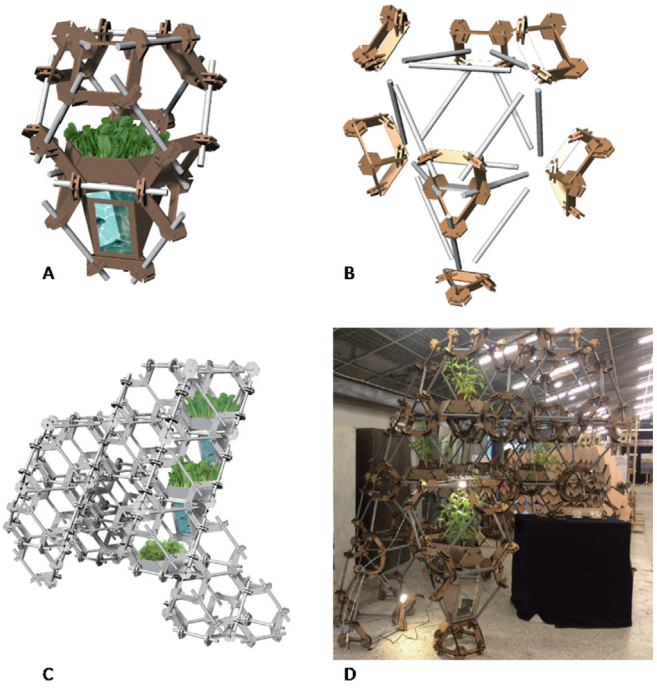

Fig. 6. Micro farm unit prototype design.
Source: AJL Design Studio team (AJL, 2016)

to form a larger unit system.

The spatial attribute ranges from a micro unit that could be place on the interior of the building and enlarged to the outdoor. The unit design takes the flexibility in space as upmost criteria in design.

Formation thinking needs to fit on the idea that it could be assembled easily in a domestic environment. The primary function includes hypo-farming use with aesthetic and environmental benefits. The preliminary stage tested the system repetition pattern and possible alternatives with material selection.

With the design of the micro-unit, activities ranging from passive to active can be incorporated and added on. Plus, the social dimension in education and fostering the relationship either within a household or at a community level is envisioned and discussed in the design ideation.

4. Discussions

4.1. Adaptive urbanism: the hybrid proposal for the green and brown agenda in the design of edible landscape

The study defined the edible greening design criteria as pertaining to the urban and architecture issues, fulfilling the role as elements inherent and pertinent to the process. Actors ranging from the dimension of the environment, spatial, economic and social dominance prevail.

This forms the basis for the green agenda or natural system and the brown agenda or human activities. As a hybrid proposal, the edible landscape is by nature a mixture of beauty, utility and health demand. It needs responding to the "changing context of landscape architectural design" (Thoren, 2014). Many people appreciate the idea of including functional plants such as edibles and herbs in ornamental plantings (Çelik, 2017); but the design thinking and best practice entail a thorough redefinition to make sure the success of the design prototype (Sousa, 2016). Edible landscape food production can take many forms and spatial expressions. We adapted Branzi's (2006) vision of the fluidity of the city and diffuse/blur the borders by an adaptive urbanism to create a reversible and evolving possibility. Psychologically, the added green element in the environment makes a contribution toward the mental wellbeing of the users by reducing their stress.

Some cities are largely self-sufficient in food produced on adjacent land areas (Deelstra and Girardet, 2000). Many urban municipalities support the growth of urban agriculture by adopting regulations enabling the addition of edible greens. A growing number of non-governmental organizations offer support to urban residents interested in growing their own food (Conway and Brannen, 2014). This is an example of 'Nature of the Space', where vacant lots or infrastructure is taken over for greening purposes. Another example is San Francisco; with its high-density urban form, the city implemented a 'parklet' system, whereby temporary pop-up parks occupy parking spaces for limited periods of time. More significantly is Seattle's Street Edge Alternatives (SEAs) program; the city installed permeable material on the surfaces along the bioswales to prevent water discharge during the dry season and wet season runoff by 98% (Horner et al., 2002). Previous research on the urban alleyway found that alley greening is mainly associated with the alley's spatial form with the type of buildings alongside and the activities created; therefore, design criteria should consider spatial features and activities. Taken from the cases of green and brown agenda case study, the proposed prototype can fit in a defined site, either indoor or outdoor. Research on urban alleyway found that alley greening is mainly associated with the alley's spatial form with the type of buildings along and the activities created; the playful configuration could aid the activities initiated, either as a willing participant or the object in which activities could happen within.

The function, description, and justification and the supportive planning strategy for the prototype design presents many possibilities. Ren Koolhaas' departing reference in the inbuilt design for the Parc de la Villette (1986) utilized a combined 'programmatic instability with architectural specificity' to generate the park; he turned the axiality of the vertical and horizontal references and redefined the positioning of architecture in respect to landscape design. The concept calls for gathering together, layering the urban over the landscape context. The study argues that place specific should consider the spatial constraint as the basis for the design. A similar gesture is observed on Tschumi's built proposal where the collective effort of landscape, architecture, and urbanism created a wide-open referential field within the urban domain. This is another dimension of the blurred boundary. The edible green system can be allocated as part of the green roof, indoor or outdoor green walls, with monitoring capacity and rainwater harvesting designer reclaimed greywater for irrigation. The cooling and biofiltration of the edible green should also be considered. The Mole Hill, in Vancouver, has taken the greening of the local alleyway with a network of edible plants in raised-bed gardens.

The natural system/green system and the integration with the human activities/brown system are implemented; the natural systems of the local, bioregion and global ecosystem used by cities and other settlements are determined. The added function of services for open space, biodiversity, water provision, waste dispersion, healthy air, and reliable climate, food is thought of in a holistic manner. The brown agenda includes the human activities for making a city livable. The total image solicits a contribution toward an active and livable environment. This produces the resilience needed for the human and economic opportunities that have driven cities throughout their history.

4.2. Planning of edible landscapes as sustainable measures

In a dynamic environment, resilience is a key consideration (McPhearson et al., 2016). Adequate maintenance of urban green spaces provides benefits by ameliorating external shocks and changes toward the resilience of cities. A compelling environmental case can be made for urban agriculture as an essential element of sustainable infrastructure. Mechanisms for engendering a biophilic experience, and three classifications of user experience: Nature in the Space, Natural Analogues, and Nature of the Space (Kellert et al., 2008). The increased development density of the urban environments, coupled with rising land values, elevate the meaning of sustainable and resilient design. The spatial continuum from new and existing buildings, to parks and streetscapes and to campus, urban and regional planning is included. The traditional planning paradigm calls for the integration of accessibility, infrastructure, communication and land use with urban development, entailing the location, size, and density on a given site within the urban plan. In Eastern Asia, urban planning master plans were driven by economic targets developed at the national level, without consideration of local needs.

In lieu of the particular context, the sustainable measure for edible landscape includes the sourcing local energy, food provision, and materials; they are part of green infrastructure development and urban agriculture and have become ever more popular. They are referred to in a variety of ways, e.g., urban gardening, urban homesteading, and edible landscaping (Nolasco, 2013). Urban agricultural landscapes are using food plants as design features in an urban landscape. Edible landscapes are part of the emergent movement in evolution in response to the slow food movement and living a greener lifestyle. Since urban farming decrease the need for arable land, urban and vertical farming could potentially improve the food production and the travel distance back to the consumers. By integrating edible greens in the urban center, the cost and environmental impact of food production and transportation from distant location could be reduced. Further, a considerable increase in productivity with a considerable decrement of inputs could be achieved in urban vertical farms (Despommier, 2011).

Other sustainable measure includes the thinking of circular system thinking, where sourcing, trade and procurement process consider the sharing and eco-efficient agenda to the green infrastructure and beyond. The water required by the system varies according to the plant selection, local air temperature, humidity, incoming solar energy, the speed of the air flow, vegetation type. Other substrate characteristics like the thickness, transfer surface, the presence of vegetation, etc. must be considered too (Franco-Salas et al., 2012). The initial investment and the size of water storage necessary must be thoroughly analyzed (Ghaffarian-Hoseini et al., 2015). The water storage system for the edible green improves the urban water quality through stormwater retention and filtration (Stav, 2008). The prototype offers a solution for the integration of photosynthetic processes in cities urban planning measure; the reduction is made to lessen the environmental impact through an emphasis on natural schemes. Green infrastructure refers to the many green and ecological features and systems, from wetlands to urban forests, which give a host of benefits to cities and urban residents (UN, 2010). Planning of the urban systems should consider the needs of the resident's demographic differences. A thorough understanding and study of the requirements from the divergent group at the commencement of design thinking offer a solid methodological tool and framework for the assessment. These result in the design that best fit the criteria and demand of the local inhabitants. This thinking not only provides a sustainable method of planning, but it also complies with the UN-HABITAT's Safer Cities Program approaches.

4.3. Edible landscape going modular and micro

Edible landscapes can play a strategic, sustainable, and multi-functional component in the urban design. Statutory municipal urban design schemes, neighborhood development projects, urban upgrading initiatives and the design of housing (Bhatt et al., 2009) can all benefit from incorporating edible landscapes. Consideration must be given to the size and scale as well as the notions of connectivity, multi-functionality and "green" (typically representing the infrastructural elements act as a basis for environmental improvement). The "core ideas" of green infrastructure can be present in nearly all definitions of the concept (Wright, 2011). Edible landscape can be placed in all types of urban spaces, ranging from a parking lot of an industrial section of a city to the center of a residential neighborhood. We observe a tendency of going modular and micro in an effort to adapt to the diverse condition in the urban system. This produces an impact on the final aesthetic and the planting selection of the given landscape.

Psychologically, the added green element in the environment makes a contribution toward the mental wellbeing of the users by reducing their stress. The research argues that the modular design of edible green best fit the exterior and interior of building. For the domestic setting, the modular design could integrate other functions of IoT home features. The exterior modular vertical greening can ease the urban heat island effect. It is a compounded result of various factors at play; the combustion heat and people, lessen evaporation cooling from the lack of local vegetation, or reduction of cooler wind on the streets, solar heat stored in the urban fabric, etc. compound the effect further (Ling and Chiang, 2017). The prototype satisfied many diverse needs and fulfilled the thermal performance of the building. The design reduces the energy consumption, mitigates the urban heat island effect, provides a natural setting for the improvement of urban biodiversity, noise reduction. Being micro in scale, the unit can be integrated with the home control system; the system can accommodate domestic features of air purification, and sensor system provides the preliminary steps forward in the automation and intelligent control with Internet of Thing (Thoren, 2014); certain intervention and envisioning criteria should be re-elaborated as a practical measure of the sustainability of the urban systems. Modular design at the micro level could integrate the land use between urban and rural (Tsubota, 2015). The design strategies accommodate the food production system. Ultimately, the feature gives back to the urban-scape and join the hand in the local/regional food system to promote amore active and sustainable lifestyle.

5. Conclusion and further research

It has been 12,000 years since humans began the agrarian lifestyle and other domestic activities that transformed the natural landscape. Only in the last 250 years, modern cities became an ordinary scene with continuous expansion toward the peri-rural land, posing obvious obstacles for sustainable development challenges increasingly concentrated in cities, particularly in the lower-middle-income countries where the pace of urbanization is fastest (UN, 2014). The urban systems have evolved into a complex living organism. It contains the necessary services, information technologies networks, transport systems, environmental component practice, microclimates, commercial information, and above all perceptive structures that produce systems of sensorial and intelligent tunnels that are contained within architecture (Branzi, 2006). As the automobile-based lifestyle has created vacant land parcels and abandoned buildings in cities, the urban systems are undergoing either a shrinking or expansion phenomenon. Climate change has increased demand for landscapes that are resilient when encountering storms, flooding, or drought. The landscape can act as a springboard for social discourse to reestablish visual, climatic, and physical connections to the sea that reaffirm the identity of the city (Thoren, 2014).

This paper argued for edible landscape as an element that directly contributes to sustainability. The exploration lays with defining edible green in several dimensions and scale. This study affirmed its value toward the spatial diversity as well as the contribution to the environmental and food production values. The systemic design thinking of the spatial, environmental, social and economic dimensions in urban edible greening was considered. From the macro-environment standpoint, urban sprawl has taken over the agricultural land for the immediate dwelling or production based activities provided for the urban core. The key to sustainability, we argue, should consider the landscape dimension within the environmental management stand in the urban landscape. The emphasis lays in the re-definition of integration issue on the urban fabric. Buildings and open spaces are key in the design criteria toward the ecological landscape in the urban systems. Enlarging the production base can create an urban agriculture that grows produce for the market. Even at the human scale, edible green contributes to the social value by creating safe places and reducing blight.

The social nature of urban farming represents a principal motivation for growing food in a city; as people and organizations work to increase access to healthful foods and connect consumers and growers. This allows for the introduction of the idea of parts to the system; in a way, becoming the manifesto for openness in architecture; the integration brings a new symbiosis between the hand of the architect and the individuality of the occupant. Architecture can then be distilled to a set of guiding, abstract and idealized principles toward a communal goal. This facilitates the social interaction among residents or even encourages immigrants to cultivate food to sell and consume (Beckie and Bogdan, 2010). The design considerably improves cross-generational interactions between youth and seniors. As demonstrated, urban agriculture is conductive toward health and well-being as well as equaling the food access and security by catalyzing more comprehensive food-access strategies in the urban centers (SPUR, 2012).

Urban agriculture provides jobs and incubation of micro business (Kobayashi et al., 2010). It acts as a viable employment opportunity and catalysts for entrepreneurial endeavors (Bradley and Galt, 2013; White, 2010). Direct benefits include the saving of food expenditures by practicing urban agriculture. The social component of urban farming is obvious, and their association with demographically higher educated and high-income social strata (Bradley and Galt, 2013; McClintock, 2013) has noticeable mobility and affordability limitation. Being just green enough demands a careful balancing act. The local stakeholders may need to contest powerful real-estate interests and mainstream environmental advocates to carry out edible green planning. If the initiation is community-based, then, the participation and success rate is anticipated as they are locally driven (Bradley and Galt, 2013). Accessibility of land is cited as the barrier most difficult to attain for urban agriculture projects (Armstrong, 2000; Campbell and Salus, 2003; Hagey et al., 2012; Kaufman & Bailkey, 2000; MacNair, 2002); the micro-unit has an obvious advantage as it could be installed individually indoor or outdoor. The integrated micro-unit can grow its own crop of judicious use fruits, herbs and vegetables; this results in a place that is flavorful, practical, visually pleasing (Creasy, 2010). But the maintenance of the edible plants requires a certain amount of attention to yield production; they may need a little extra watering, pruning, fertilizing, or pest management (Beck and Quigley, 2001). To reduce maintenance requires planting the "right plant in the right place."; selective judgment must be made to fit with the local conditions. The exact scheduling by keeping a growth chart is necessary for efficient management. Keeping up with ripening fruits and vegetables may require weekly, or even daily, monitoring during the harvest period. Highly perishable crops will need either quick processing of canning, freezing or drying, or friends and neighbors to accept the abundance (Worden and Brown, 2007). The aid of technology in maintenance management requires precise control of the climate control and lighting necessary for the plants, including the integration with cooling/heating systems (Ehrenberg, 2008).

This paper brought forth alternative consideration and design

criteria for urban edible on a micro scale. The proposed prototype could serve both as a landscape media as well as edible production with obvious social and health contribution. The design thinking of a prototype incorporates the systemic concept that could allow the stacking into various forms, allowing flexibility and continuous adaptation to the local need and function. The study demonstrates the advantages of promoting such units in an urban and non-urban setting where the access to edible greens is scarce. Ecologically, the use of edible green in urban planning could bring forth realistic chance of community bonding and social interaction, with economic advantages. Edible green in the micro-unit provides explicit advances in public health, environmental equity and social justice in urban communities. But the active involvement of urban planners, designers, and ecologists are essential to articulate strategies for urban green space. Further research should concentrate on the technology integration with the spatial unit as well as a further empirical study on the total system application pertinent to edible green design.

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